REPORTS ON ENVIRONMENTAL STUDIES NEAR DRYDEN LAGOON, 1985.

1. Air Quality Survey
2. Moss and Vegetation Studies
3. Bacterial Levels

Ontario

Ministry of the Environment

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Regional Director

Technical Memorandum

Ambient Air Quality Survey in the Vicinity of Great Lakes Forest Products Limited Dryden, Ontario

July, 1985

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Prepared for:

Northwestern Region
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EXECUTIVE SUMMARY

At the request of the Northwestern Region of the Ministry of the Environment, Mobile Air Monitoring Unit #1 undertook an ambient air survey in the vicinity of the Great Lakes Forest Products Limited kraft and fine paper mill and secondary treatment system (lagoon) in Dryden between July 6th and 22nd, 1985.

The main purpose of this survey was to investigate gaseous emissions from the lagoon and mill complexes. Specific hydrocarbons and total reduced sulphur compounds were the designated contaminants of interest. Approximately 314 hours of continuously monitored ambient air data and 61 30-minute gas chromatographic samples were acquired during this survey.

The lagoon was found to be a significant source of total reduced sulphur compounds and hydrocarbons. It was also found that the concentration of these compounds decreased rapidly as the distance from the lagoon increased. The Provisional Guideline for TRS was not exceeded at the downwind sites off company property. However, levels above the nominal odour threshold were measured at nearby residences.

For monitoring on company property beside the lagoon, the maximum 30-minute average concentration of total reduced sulphur compounds was found to be 0.539 ppm (parts per million). The total hydrocarbon loadings ranged from 219 to 652 $\mu g/m^3$ (micrograms per cubic metre) and the aromatic fraction accounted for up to 74 percent of the total hydrocarbons detected. The most prominent aromatic was 1-isopropyl-4-methylbenzene (para-cymene). This is a naturally occurring hydrocarbon, derived from trees, for which there is no Environmental Guideline. Trichloromethane (Chloroform) was the dominant chlorinated organic detected in these on-site samples and its maximum loading was 196 $\mu g/m^3$ (its Environmental Guideline is 1,500 $\mu g/m^3$). For the off-site, downwind gas chromatographic samples, the total hydrocarbon loadings were at or near background levels. For all the other common contaminants such as oxides of nitrogen, carbon monoxide

and ozone, all concentrations were found to be at or near background levels.

From measurements acquired downwind of the main mill complex, the Provisional Guideline for the total reduced sulphur compounds was exceeded during 4 of the 16 applicable monitoring periods. The maximum 30-minute average concentration of total reduced sulphur compounds reported for this phase of this study was 0.154 ppm - i.e. over 5 times the Guideline. These measurements of TRS were in general agreement with the concentrations monitored by Northwestern Region's fixed station over the past few years. At all sites, the nominal odour threshold for TRS was exceeded. From the analyses of the 31 gas chromatographic samples acquired downwind of this mill, all hydrocarbon loadings were considered to be at or near background levels. For all the other common contaminants such as oxides of nitrogen, carbon monoxide and ozone, the concentrations were found to be at or near background levels.

Levels of particulate matter monitored in the vicinity of the lagoon were generally very low. The major source of particulate matter for the two samples which exceeded the air quality criterion was road dust. Only small amounts of foam from the lagoon were detected on occasion at each of the four sampling locations.

CONCLUSIONS

In this section, only the most significant points identified by this study are presented. The reader is referred to the previous sections of the report for a full discussion of any of these items.

In point form, here are the findings.

1. Lagoon Study:

   - Significant concentrations of TRS (total reduced sulphur) compounds were measured on company property surrounding the

lagoon. The maximum 1-minute average concentration of TRS was in excess of 12.5 ppm and the maximum 30-minute average concentration was 0.539 ppm.

- Off plant property, the concentrations of TRS decreased rapidly as the downwind distance increased. At nearby residences, the concentrations were in excess of the odour threshold for TRS (approximately 0.005 ppm), however, no exceedence of the Provisional Environmental Guideline (0.027 ppm) was measured.

- Carbonylsulphide and carbon disulphide measurements at the lagoon indicated essentially uniform concentrations (all below 0.04 ppm) throughout the different areas of the lagoon. These concentrations were below the standard (0.10 ppm) for carbon disulphide. There are no standards or guidelines for carbonylsulphide.

- The lagoon was also found to be a source of non-methane hydrocarbons (TH-M). The maximum 30-minute average concentration of TH-M as measured at the surface of this lagoon was found to be 29.51 ppm. Similar to the TRS findings, these concentrations decreased rapidly as the downwind distance from the lagoon increased. Beyond approximately 175 metres, the concentrations of TH-M were at or near background levels. No Environmental Standards, Criteria nor Guidelines exist for TH-M.

- The average total hydrocarbon loadings on plant property beside the lagoon ranged from 219 to 652 $\mu g/m^3$. For these totals, the aromatic fraction dominated and accounted for up to 74 percent of all the organics detected.

- The most prominent aromatic was 1-isopropyl-4-methylbenzene (p-cymene). Its maximum concentration was 1741 $\mu g/m^3$ but this is only 0.2 percent of the concentration reported to cause skin irritation.

- Small amounts of chlorinated organic compounds were detected in these GC samples. The most prominent of these was tri-

chloromethane (chloroform) and its maximum concentration was 197 $\mu g/m^3$. The Environmental Guideline for this organic is 1500 $\mu g/m^3$.

- The concentrations determined by GC analyses followed the TH-M results. Thus, at downwind distances greater than 175 metres, the GC analyses reflected background hydrocarbon concentrations.
- Apart from TRS and non-methane hydrocarbons, the concentrations of the other continuously monitored contaminants were at or near background levels.

2. Main Mill Complex:

- Downwind of this mill complex, the TRS Provisional Guideline (0.027 ppm) was exceeded during 4 of the 16 monitoring periods. The maximum 30-minute average ground level concentration (glc) of TRS was 0.154 ppm. - i.e. over 5 times the Guideline. The TRS odour threshold (i.e. approximately 0.005 ppm) was exceeded during all 16 monitoring periods.
- For the other continuously-monitored contaminants, background concentrations were measured.
- From the analyses of 31 GC samples acquired downwind of the mill, all hydrocarbon concentrations were considered to be at or near background levels.

3. Overnight Monitoring (at the MNR site):

- The TRS odour threshold was exceeded during 8 of the 15 monitoring periods.
- On one occasion, the TRS Provisional Guideline was also exceeded. The maximum 30-minute average TRS glc was 0.037 ppm and this coincided with reported high TRS stack measurements at the mill.
- The other continuously monitored concentrations were at or near background levels.

4. Particulate Matter (vicinity of the lagoon):

- Levels of total suspended particulate were generally very low. The highest geometric mean recorded at any of the four sites was 42 $\mu g/m^3$.
- Forty-six particulate samples were acquired and two of these had total suspended particulate loadings in excess of the applicable Air Quality Criterion of 120 $\mu g/m^3$. However, the major cause of the high readings in these two samples was road dust.
- Small amounts of foam were occasionally detected on filters exposed at each of the four sampling locations. However, the amounts were too small to the quantified.

MOSS EXPOSURE AND VEGETATION SAMPLING STUDIES
in the vicinity of the
SECONDARY TREATMENT SYSTEM
operated by
GREAT LAKES FOREST PRODUCTS LIMITED, DRYDEN
1983, 1984, 1985

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INTRODUCTION

The Ontario Ministry of the Environment conducted moss exposure studies in 1983 and 1984 around a secondary treatment system (lagoon) in Dryden. The lagoon processes liquid effluent from the Dryden pulp and paper mill operated by Great Lakes Forest Products Limited (the "company"). The studies showed that chloride and sodium levels in moss at some locations on company property were significantly higher in 1984, the first year of lagoon operation, than in 1983, before the lagoon was formed (1, 2).

The company installed sprayers in the aeration basin (eastern end of the lagoon) in the spring of 1985 to suppress the development of wind-borne foam. To assess the possible effects of spray drift from the sprayers, a third moss exposure survey was conducted during the summer of 1985. Observations were made of spray drift and foam conditions. Local vegetation was also examined for evidence of contaminant injury and was sampled for chemical analysis.

METHODS

Open-mesh bags containing dried Sphagnum moss were exposed from July 15 to August 20, 1985 at 19 sites around the lagoon (Figure 1). Similar dates were used for the surveys in 1983 (11 sites) and 1984 (18 sites). After exposure, all moss samples were submitted to the Ministry's Thunder Bay laboratory for mercury and sodium analysis, and to the Ministry's Toronto laboratory for chloride analysis. Chloride and sodium were selected as tracers of foam particles and spray drift. Mercury was analysed because of historical mercury pollution problems at the Dryden mill. Standard Ministry procedures were followed for moss bag fabrication, exposure, sample processing and analysis (3, 4, 5).

Four moss exposure studies, using moss provided by the Ministry, were also conducted by the company between May and September, 1985, at six locations (Figure 2). Samples from the company studies were analysed by the Ministry.

Trembling aspen foliage was collected from trees at three sites along a line to the south of the lagoon (Figure 1) and at two control locations remote from the study area. These samples were analysed for the same elements as the moss. Vegetation around the lagoon was carefully examined for signs of damage caused by insects, disease, contaminants or other stress factors.

Proposed contaminant guidelines developed by the Ministry for moss exposure studies and for deciduous vegetation are used in this report. Their exceedance suggests that contamination may be present but does not necessarily imply adverse effects.

RESULTS

MOSS EXPOSURE SURVEYS

Chemical analysis results from the three Ministry surveys are summarized in Table 1. In the 1983 pre-operational survey, all contaminant levels were normal, except for two elevated mercury values on company property. These values are probably anomalies, since mercury concentrations at both sites were in the normal range in 1984 and 1985.

In the 1984 and 1985 surveys, mercury levels met the Ministry guideline at all sampling locations, both on and off company property. With one exception (site 15 in 1985), chloride also met the guideline at off-property sites. It was significantly above the guideline at some locations on company property in both years. Sodium was sharply higher at all sites in 1984 and 1985 than in 1983. The guideline was exceeded at many sites on company property, but there was only one exceedance (which occurred in 1985) off-property. The distribution pattern for

sodium in moss in 1985, shown in Figure 3, is similar to that for chloride and sodium in 1984 and chloride in 1985.

Data from the moss surveys conducted by the company are presented in Table 2. Although concentrations of chloride and sodium varied substantially from month to month, the data showed that the lagoon was a source of airborne chloride and sodium. At the only off-property site in the company surveys (site 6), sodium consistently met the Ministry's contaminant guideline. Chloride slightly exceeded the guideline at this location in the May-June exposure period.

Chemical analysis data from both the Ministry and company surveys are supported by observations from Ministry staff, which indicate that spray drift may cross the southern property boundary of the lagoon under the influence of strong winds.

VEGETATION ASSESSMENT

Willow shrubs in the study area were severely injured by the grey willow leaf beetle (Pyrrhalta decora decora). Similar damage to willow was widespread in northwestern Ontario in 1985. An anthracnose disease also caused conspicuous damage to leaves on trembling aspen trees near site 12 (Figure 1) and injured balsam poplar trees on the south bank of the Wabigoon River near site 5. No vegetation injury attributable to air pollutants was noted.

Chemical analysis results for trembling aspen foliage (Table 3) were similar to those for moss; chloride and sodium levels were highest near the aeration basin and decreased as distance from the basin increased. Mercury concentrations were normal at all locations. Sodium levels at the two off-property sites exceeded the Ministry guidelines, while chloride was in compliance.

CONCLUSIONS

The moss exposure studies conducted by the Ministry and the company showed that the aeration basin of the lagoon was an intermittent source of airborne contaminants containing chloride and sodium. These results were confirmed by analysis of local vegetation. Spray drift and wind-blown foam particles from the aeration basin were the probable causes of elevated chloride and sodium in dried moss and in living vegetation. Based on these studies, contaminant fallout was restricted mostly to company-owned property surrounding the lagoon. Direct observation of spray drift and analysis of samples showed, however, that some contamination extended beyond the company property line to the south of the aeration basin part of the lagoon.

The company is aware that certain wind conditions permit off-property spray drift, and has taken corrective action to prevent this from recurring in future.

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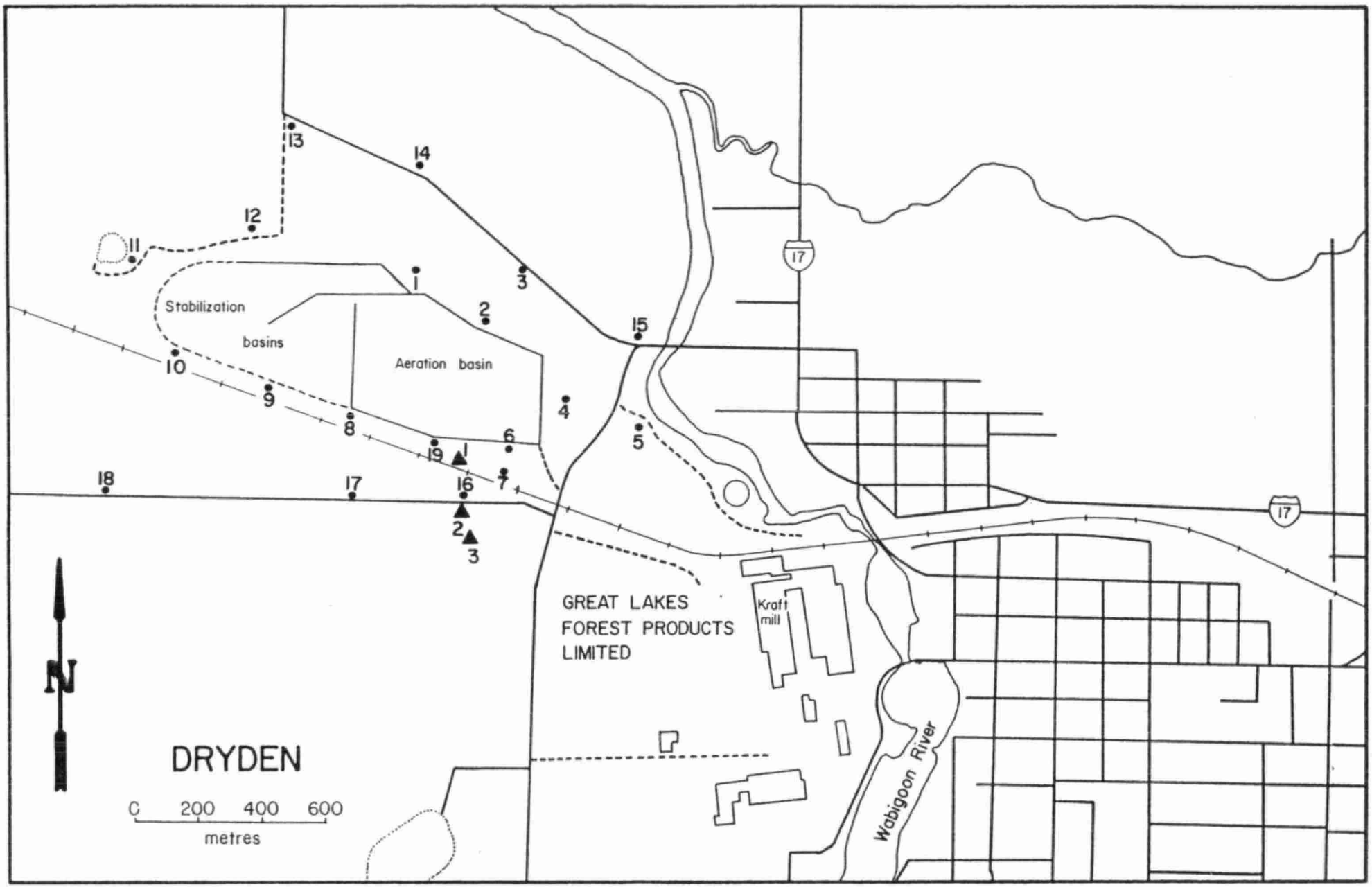

Figure 1. Moss bag exposure and vegetation sampling sites, Dryden, 1985. (▲ vegetation ; • moss bag)

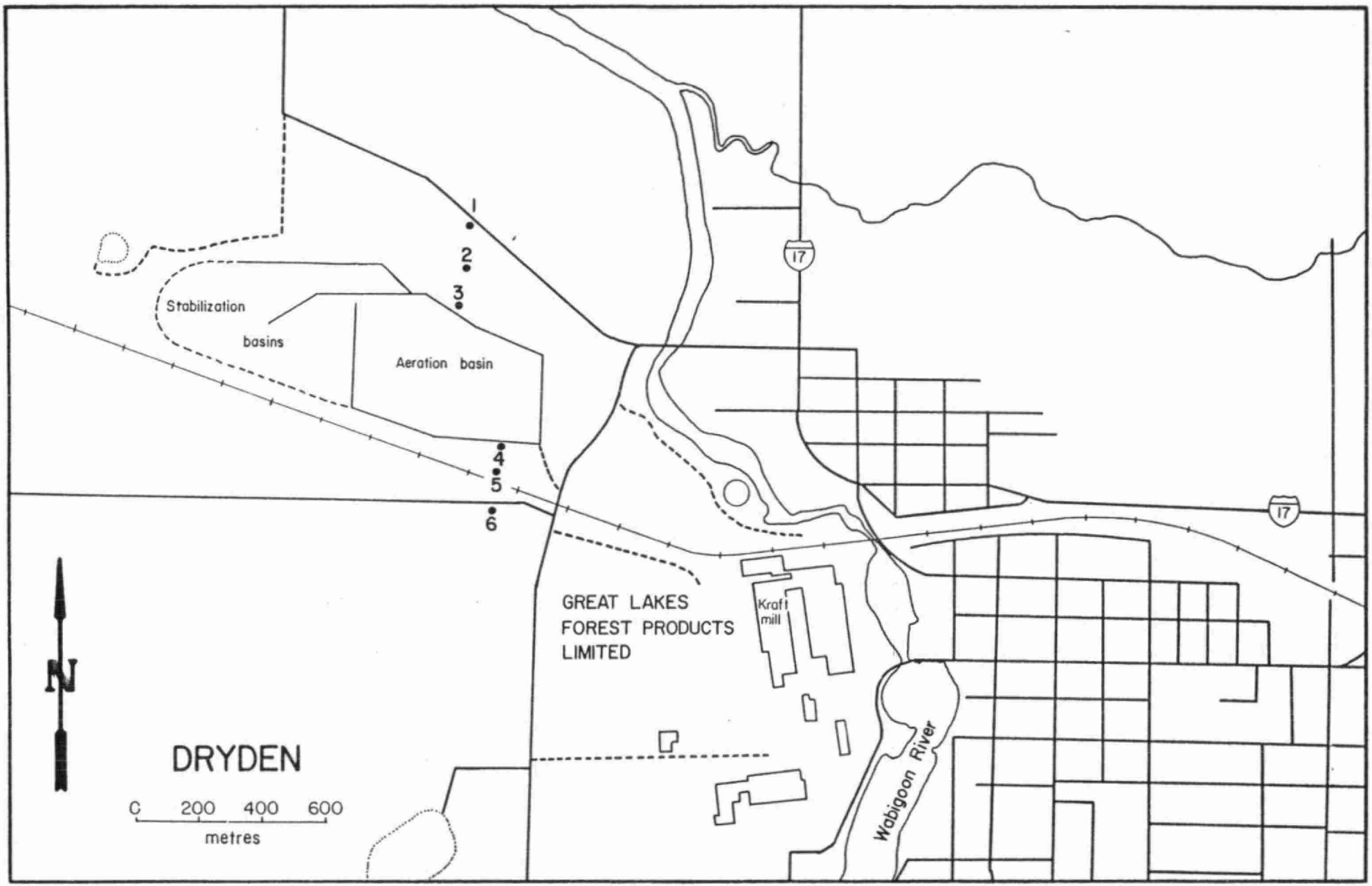

Figure 2. Monthly moss bag exposure sites used by Great Lakes Forest Products Limited, Dryden, 1985.

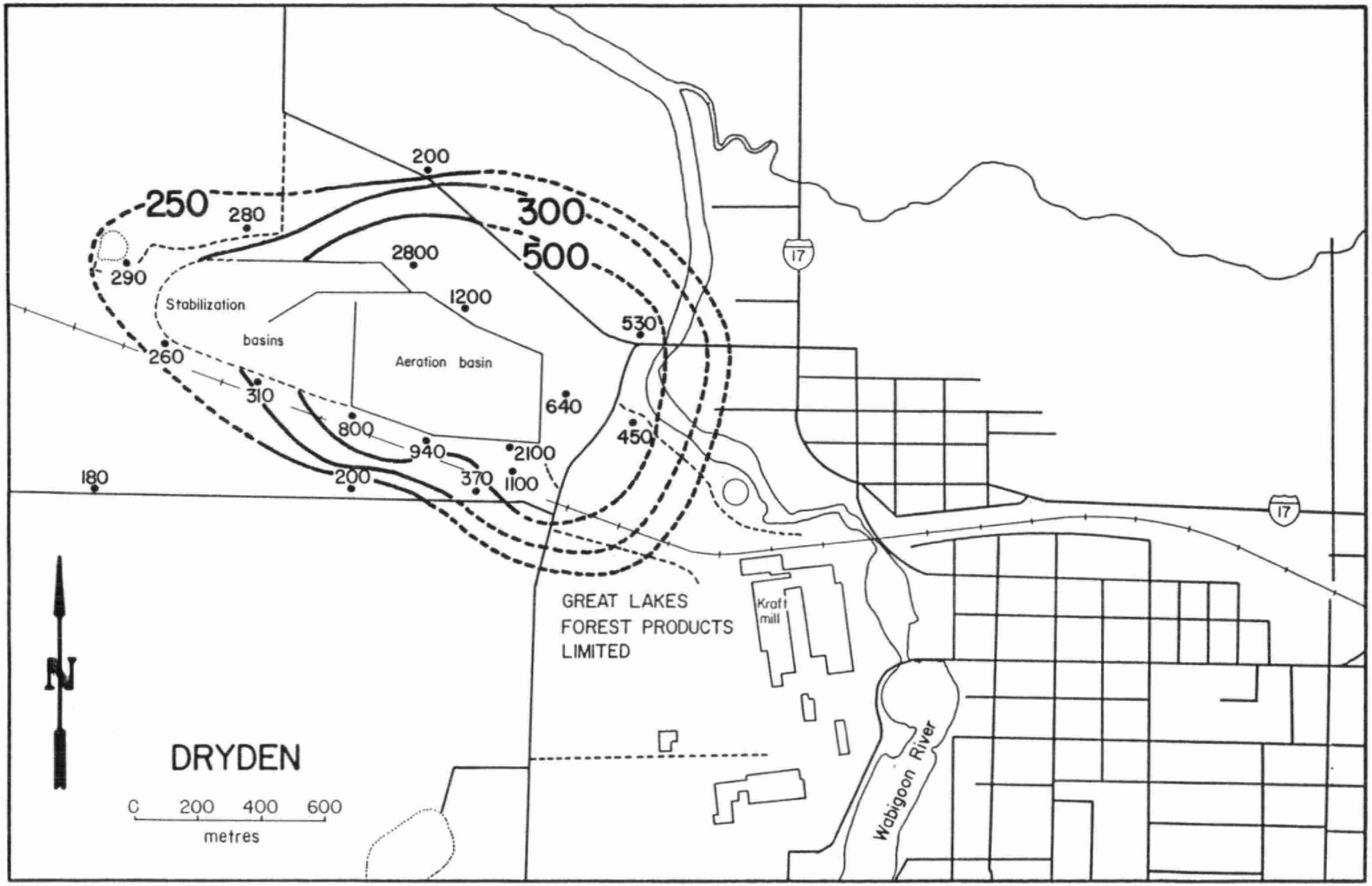

Figure 3. Levels of sodium (µg/g, dry weight) in exposed moss, Dryden, 1985.

TABLE 1. Comparison between levels of chloride (%, dry weight), mercury and sodium (µg/g, dry weight) in moss bags exposed near the secondary treatment system (lagoon) in Dryden, July 19 - August 17, 1983, July 18 - August 24, 1984, and July 15 - August 20, 1985.

Station	Chloride			Mercury			Sodium		
	1983	1984	1985	1983	1984	1985	1983	1984	1985
1	0.01		0.17	0.11		0.09	120		2800
2	0.01	0.10	0.07	0.13	0.16	0.12	90	1300	1200
3	0.02	0.03	NA[b]	0.11	0.15	NA	86	380	NA
4	<0.01	0.38	0.04	0.07	0.15	0.14	100	3700	640
5	0.03	0.02	0.02	0.07	0.14	0.11	150	480	450
6	<0.01	0.05	0.17	0.35	0.11	0.12	<25	770	2100
7	<0.01	0.03	0.08	0.10	0.15	0.10	47	250	1100
8	<0.01	0.04	0.02	0.08	0.16	0.08	<25	200	800
9	<0.01	<0.01	<0.01	0.10	0.14	0.10	51	120	310
10	<0.01	0.01	<0.01	0.10	0.15	0.09	45	150	260
11	<0.01	0.04	<0.01	0.31	0.17	0.11	57	380	290
12		<0.01	0.01		0.16	0.09		230	280
13		0.02	NA		0.15	NA		190	NA
14		<0.01	<0.01		0.13	0.10		180	200
15		0.02	0.06		0.20	0.10		180	530
16		0.03	0.03		0.13	0.10		200	370
17		0.01	0.02		0.14	0.08		120	200
18		<0.01	0.02		0.14	0.10		97	180
19			0.05			0.10			940
Exposed controls	<0.01	<0.01	<0.01	0.08	0.13	0.10	42	99	56
Unexposed controls	<0.01	<0.01	0.03	0.07	0.15	0.09	72	68	84
Proposed contaminant guideline[a]		0.03			0.20			250	

[a]Based on a 30 day exposure period. [b]Not available (sample knocked to ground during exposure period).

TABLE 2. Levels of chloride (%, dry weight) and sodium (µg/g, dry weight) in moss exposed near the secondary treatment system (lagoon) in Dryden, 1985[a].

Site	May 17 - June 17		June 17 - July 17		July 17 - Aug 17		Aug 17 - Sep 17	
	Na	Cl	Na	Cl	Na	Cl	Na	Cl
1	360	0.02	260	0.04		0.08	290	0.04
2	820	0.02	600	0.06	1100	0.14	550	0.09
3	260	0.01	990	0.12	1200	0.13	2400	0.31
4		0.05	4400	0.71	930	0.03	1800	0.21
5	590	0.03	1800	0.24	420	0.03	460	0.06
6	160	0.05	190	0.02	110	<0.01	100	0.02
Exposed control			100	<0.01	110	<0.01	62	<0.01
Unexposed control			78	<0.01	100	<0.01	100	<0.01
Proposed guideline[b]	250	0.03	250	0.03	250	0.03	250	0.03

[a]Moss bags were set out and collected by Great Lakes Forest Products Limited.

[b]Based on a 30 day exposure period.

TABLE 3. Levels of chloride (%, dry weight), mercury and sodium (µg/g, dry weight) in trembling aspen foliage collected August 19, 1985, Dryden.

Site	Chloride	Mercury	Sodium
1	0.41	0.01	1600
2	0.10	<0.01	330
3	0.09	0.04	120
Controls	0.11	<0.01	<25
Proposed guidelines	0.15	0.10	50

BACTERIAL LEVELS IN THE AERATION BASIN OF THE SECONDARY TREATMENT SYSTEM (LAGOON) GREAT LAKES FOREST PRODUCTS LIMITED, DRYDEN.

September, December, 1985

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INTRODUCTION

During the past two years, residents living near the Great Lakes Forest Products secondary treatment system (lagoon) at Dryden have expressed concern that dried foam blowing from the lagoon poses a health hazard. However, health authorities have indicated that the dried foam was not a health threat. More recently, following the installation of sprayers in the aeration basin part of the lagoon, residents have enquired about the possible health effects from spray drift. To investigate this situation, a study to characterize and enumerate the bacteria in the lagoon was undertaken.

The material blowing off-site (dried foam and/or spray drift) would be likely to pose a health hazard only if pathogenic (disease-causing) organisms were present. The bacterial levels in the dried foam and spray drift would be expected to be substantially less than those occurring in the liquid of the lagoon because of the adverse effects of drying on the bacteria. Therefore, if pathogens were present, they should be detected more easily in the liquid of the lagoon rather than in the dried foam or spray drift. For this reason, only the lagoon liquid was examined in this study.

The purposes of the present study were to:

- Determine whether or not selected types of pathogenic bacteria were present in the liquid of the lagoon.
- Determine the presence or absence of bacterial indicators of domestic waste in the aeration lagoon.

METHODS

All methods and materials in this study employed standard, recognized techniques, or slight modifications of such techniques to accommodate the nature of the material being examined. In

addition, several new methods reported in recent literature for the detection and enumeration of Escherichia coli (E. coli) were also employed.

Two samples of the lagoon liquid, collected three months apart, were examined. The first sample was collected September 5, 1985, the second sample on December 5, 1985. Each sample was collected from the mid-point of the south side of the aeration basin, approximately in the centre of the area where sprayers were installed. The samples were submitted to the Ministry's Thunder Bay laboratory for bacterial examination on the day of collection.

The samples were examined for a variety of sanitary bacterial indicators and pathogenic bacteria. The methods and media employed for each bacterial test are listed in Table 1. Some of the bacterial groups were enumerated using several different methods. The bacterial parameters analyzed included the following groups or species of bacteria: total coliforms, fecal coliforms, fecal streptococci, Pseudomonas aeruginosa, heterotrophic bacteria, Klebsiella species, Klebsiella pneumoniae, Staphylococcus species, Salmonella species, standard-plate count bacteria, Clostridium perfringens, and fluorescent group pseudomonads. In addition, some of the bacteria in several of the groups were biochemically identified to genus and species using API-20E, a standard multi-test system.

RESULTS

Heterotrophic bacteria were the most common group of bacteria in the samples of the lagoon liquid. These bacteria were present at a level of 10^9 per 100 millilitres. Approximately one-half of these organisms were oxidase-positive and were identified as belonging to the "fluorescent-pseudomonas group." The most common bacteria in the remainder of the heterotrophic group were Klebsiella, Citrobacter or Enterobacter species.

The second most common group of bacteria were total coliforms. These were present at a level of 10^7/100 ml. The most numerous type of bacteria in this group was a Klebsiella species. Pseudomonas aeruginosa was recovered at a level of 10^4/100 ml. Fecal coliforms were also found at a level of 10^4 while fecal streptococci occurred at a concentration of approximately 10^3/100 ml.

E. coli, Salmonella sp., Clostridium perfringens and Staphylococcus aureus were not detected in either of the samples by any of the methods that were employed.

DISCUSSION OF RESULTS

As expected, the liquid of the Great Lakes Forest Products lagoon at Dryden was found to contain high levels of bacteria. However, these levels are not unique to this lagoon. Similar numbers and types of bacteria have been isolated from pulp and paper mill effluents across North America. Health authorities have indicated that these organisms in dried foam from this lagoon, and from a similar system in Fort Frances, "do not present a substantial additional risk over their natural occurrence in the environment."

Salmonella, Clostridium and Staphylococcus were selected as examples of pathogenic bacteria that might be present in the lagoon. None of these three types of bacteria were detected. Again, this result was expected, since these organisms would have to compete successfully with the high levels of Klebsiella, and fluorescent-pseudomonads that grow in this system. Pathogenic bacteria would be detected only if they were present in relatively high numbers as a result of growing in the lagoon. Without the ability to grow, these organisms, if present, would simply be washed out of the lagoon.

The relatively high level at which Pseudomonas aeruginosa was recovered indicates its ability to grow in this system. This

organism appears to be part of the natural flora of this lagoon and has been found in effluent samples from other pulp and paper mills.

Escherichia coli was employed as the prime indicator of the presence of domestic waste (sewage) in the aeration lagoon. This organism was not detected and, therefore, it appears that there is no domestic waste entering the lagoon. This coincides with information supplied by Great Lakes Forest Products officials that no domestic waste has entered the lagoon since June 30, 1985. Therefore, there is little possibility that pathogens commonly associated with sewage are being continually introduced into the system.

CONCLUSION

No pathogenic bacteria of domestic waste origin were detected in the lagoon liquid. If pathogenic organisms could not be demonstrated in the liquid phase, it would be very unlikely that they would be present in either dried foam or in spray drift. Therefore, no further work is proposed to examine dried foam or spray drift for bacterial pathogens.

Table 1. Levels of selected indicator and pathogenic bacteria in the aeration lagoon, Great Lakes Forest Products, Dryden, 1985.

Bacterial Parameter	Sample date	Test method	Primary medium	Incubation conditions	Secondary medium	Incubation conditions	Further tests	Bacterial levels (per 100 ml)
Heterotrophic bacteria	Sept. 5	S.P.[1]	C.P.S. agar	20°C, 7 days	-	-	-	4.7×10^9
Heterotrophic bacteria	Sept. 5	S.P.	C.P.S. agar	35°C, 48 hrs	-	-	-	5.5×10^9
Heterotrophic bacteria	Sept. 5	M.F.[2]	m-SPC agar	35°C, 48 hrs	-	-	-	2.0×10^9
Oxidase-positive bacteria	Dec. 5	M.F.	m-SPC agar	35°C, 48 hrs	-	-	In-situ oxidase	Approx. 10^8
Fluor. group pseudomonads	Dec. 5	M.F.	m-SPC agar	35°C, 48 hrs	-	-	API-20E	Approx. 10^8
Total Coliforms	Dec. 5	M.F.	m-Endo LES	35°C, 22 hrs	-	-	-	6.6×10^7
Klebsiella sp.	Dec. 5	M.F.	m-K agar	35°C, 48 hrs	-	-	API-20E	Approx. 10^7
Citrobacter sp.	Dec. 5	M.F.	m-K agar	35°C, 48 hrs	-	-	API-20E	Approx. 10^7
Enterobacter sp.	Dec. 5	M.F.	m-K agar	35°C, 48 hrs	-	-	API-20E	Approx. 10^7
Fecal Coliforms	Sept. 5	M.F.	m-TEC agar	44.5°C, 23 hrs	-	-	-	3.0×10^4
Fecal Coliforms	Dec. 5	M.P.N.[3]	LT. broth	35°C, 24-48 hrs	EC medium	44.5°C, 24 hrs		1.7×10^4
Pseudomonas aeruginosa	Sept. 5	M.F.	m-PA-E	41.4°C, 72 hrs	-	-	-	1.7×10^4
Citrobacter freundii	Dec. 5	Spread	MacConkey agar	35°C, 20 hrs	-	-	API-20E	Approx. 10^5
Klebsiella pneumoniae	Dec. 5	M.P.N.	LT. broth	35°C, 24-48 hrs	EC ,medium	44.5°C, 24 hrs	API-20E, gas @44.5, No growth @10°C	5.4×10^3
Escherichia coli	Dec. 5	M.F.	$m\text{-}TEC_{IG}$	44.5°C, 23 hrs	-	-	-	N.D.[4] (L100)
Escherichia coli	Sept. 5	M.F.	$m\text{-}TEC_{IG}$	44.5°C, 23 hrs	-	-	-	N.D. (L10)
Escherichia coli	Sept. 5	M.P.N.	LTB_{MUG}	35°C, 72 hrs	-	-	-	N.D. (L10)
Staphylococcus aureus	Sept. 5	S.P.	M.S.A.	35°C, 48 hrs	-	-	-	N.D. (L100)
Salmonella sp.	Sept. 5	grab	P.B.P.	35°C, 24 hrs	Tetrathionate	35°C, 24-48 hrs	B.G.S. agar, T.S.I.	N.D. (L1/5L)
Clostridium perfringens	Sept. 5	M.P.N.	Skim milk	35°C, 96 hrs	-	-	-	N.D. (L1)

[1] S.P. = Spot plate method
[2] M.F. = Membrane filter method
[3] M.P.N. = Most probable number method
[4] N.D. = Not detected

DATE DUE		